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Feasibility of using Toothpaste Industry Sludge Containing $CaCO_3$ in Manufacturing Bricks

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***Abstract*— Bricks are one of the major building construction materials and are widely used around the world. Clay is the main component of brick. In this study, an effort has been made to utilize the toothpaste sludge (i.e. waste product of toothpaste industry) in bricks. The objective of this present work is to study the stabilization and solidification of industry sludge and then to study engineering behavior of this stabilized and solidified sludge. This paper presents an experimental investigation carried out to analyze the feasibility of using toothpaste sludge waste to reduce the quantity of clay as there is a greater shortage of clay in many parts of the world. Initially, XRF characterization of toothpaste sludge has been carried out. The bricks are prepared by toothpaste sludge with varying compositions reduced the quantity of clay by 10%-50%. From experimentation, it is observed that waste created bricks are light weighted, sound, water absorbing and meet compressive strength requirements.**

Keywords: Bricks, industrial waste material, toothpaste sludge, light weight, compressive strength

I. INTRODUCTION

The construction industry is one of the important pillars of any nation. As India is under development, the growth of construction industry in India is very fast. There is a huge demand of good quality construction for which the basic requirement is good quality building materials. Brick is one of the most important and widely used building material all over the world. It is among the oldest and most sempiternal building materials. It is the simplest of all building materials. Brick is made up of clay and water which is then hardened by drying and burning. Some of the important characteristics of bricks that make it popular building material are its highly economical cost, high compressive strength and good durability. There is an increase in demand of bricks which is resulting in the escalation of cost in India. This problem can be tackled by using some waste material to replace some part of the primary component which in turn can also solves the disposal problem of the waste material. This will also help in economizing the resources. It will help in conservation of resources and reducing pollution. Also, there will be reduction in construction cost. One such material is toothpaste industry sludge. Huge amount of dry toothpaste sludge is produced on daily basis. There are two ways to solve the problem. One is the disposal of solid or dry waste like land filling and the other is using it as fertilizers. But even then, some harmful material is still inside the sludge which causes environmental pollution.

Few studies have been performed on utilizing sludge materials in the process of brick making. The clay which is excavated is mixed with sludge to improve brick properties. The study presented investigation of effect of textile mill sludge in burnt clay. It showed that textile mill sludge upto 15% can be added to get a compressive strength of 3.5 N/mm^2 and water absorption of 20%.(Shrikant S Jahagirdhar,May 2013). Another study showed that the brick earth can be replaced with treatment plant sludge upto 40% by weight and are more durable (G.Reddy Babu, June 2013). Another study presented the result of utilization of dry sludge from water treatment plant as building material. It showed that the maximum percentage that can be mixed with the clay is 50%.(JooHwaTay, 1987).

So, we decided to replace dry toothpaste sludge as soil. Experiments have been performed to study the effect of 10-50% clay replacement with toothpaste sludge.

II. MATERIALS AND METHODS

A. Materials Used

Materials used in the study were locally procured. The toothpaste sludge was taken from a local toothpaste making factory. The clay soil was also taken from a nearby locally based brick kiln. The sludge was kept in containers. It was available in powdered form. The physical properties of sludge were as per Table-1. The chemical composition was calculated from XRF tests. The composition is described as below in table 2(a&b).

Table-1: Physical Properties of Material Used

Material	Specific Gravity	Fineness Modulus
Toothpaste Sludge	2.38	2.51

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Table-2a: Chemical composition Clay

S. no.	Component	Percentage
1	SiO_2	67
2	Al_2O_3	26
3	Fe_2O_3	3
4	Na_2O	1
5	MgO	1
6	P_2O_5	Trace
7	SO_3	0.5
8	K_2O	2
9	CaO	0.1
10	Cr_2O_3	Trace
11	MnO	Trace
12	NiO	Trace
13	CuO	Trace
14	ZnO	Trace
15	Cl	Trace

Table-2b: Chemical composition of toothpaste sludge

Composition	Percentage
O	50.15%
Ca	20.61%
Si	20.55%
C	7.23%
Na	0.64%
S	0.39%
Mg	0.26%
Al	0.07%
Cl	0.03%
P	0.03%
Fe	0.02%
Sr	0.01%
K	53ppm
Cu	14ppm
Zr	5ppm

B. Mixing and Proportions

Sludge is mixed properly in the ingredients of brick in desired proportion. Sample prepared from all these mixes were compared and tested for several strength parameters. Fig 1 shows pictures of bricks while mixing and formation.

Fig 1: Figures of bricks while mixing and formation

Mix proportions of several mixes are as in Table-3.

Table-3: Mix Proportions of trial mixes

S. no	Die	Soil(kg)	Sludge (kg)	Sludge %	Identity
1	Sk	80	0	0	B1
2	Sk	72	8	10	B2
3	Sk	64	16	20	B3
4	Sk	56	24	30	B4
5	Akm	48	32	40	B5
6	Akm	40	40	50	B6

C. Weight of the brick after formation

The weight of a few samples of each type was taken and then average weight was found out to get the desired standard weight. The average weight of each type is given below:

Table-4: Weight of Bricks

S. no.	Brick type	Weight(kg)
1	B1	2.920
2	B2	2.228
3	B3	1.950
4	B4	1.831
5	B5	1.765
6	B6	1.313

D. Water Absorption

The bricks of each type were dipped in water tank and water absorption was found out on a period of 24 hours. The table 5 below shows the weight of each type and the percentage of water absorption after standard time.

Table-5: %age absorption after 24 hours

S. no.	Brick Type	Initial Weight	24 hours weight	% weight after absorption
1	B1	3.008	3.480	15.70
2	B2	2.232	2.600	16.50
3	B3	1.878	2.201	17.20
4	B4	1.763	2.161	22.60
5	B5	1.712	2.237	30.70
6	B6	1.363	1.908	41.20

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Fig 2 below shows the pictures of water absorption process in which each brick was dipped in separate container containing water.

Fig 2: Water Absorption of bricks

E. Compressive Strength

The bricks casted were tested for compressive tests by firstly curing the bricks for a day and then a mixture of cement and aggregate was added to it in ratio 1:3 in the frog section. The bricks were then covered with a damp jute bag for a day and then bricks were cured for 3 days. After drying, the compressive strength was tested in UTM. Following table 6 shows the amount of compressive strength of bricks.

Table 6: Compressive strength of bricks

S. no.	Bricks type	Compressive strength (N/mm^2)
1	B1	13.50
2	B2	13.6
3	B3	13.4
4	B4	7.4
5	B5	6.5
6	B6	4.5

Fig 3 below shows compressive strength test on Universal testing machine.

Fig 3: Compression Test on UTM

F. Efflorescence Test

The bricks were tested for efflorescence by placing them in tray in vertical position and adding 25cm water twice. Then physical examination was done. Table 7 below shows the results for efflorescence.

Table-7: Efflorescence of bricks

S. no.	Brick type	Efflorescence
1	B1	Nil
2	B2	Nil
3	B3	Nil
4	B4	Slight
5	B5	Slight
6	B6	Slight

G. Soundness Test

Two bricks of same type were taken and struck against each other. If it does not break and a metallic ringing sound forms then the bricks are sound. Table 8 below shows the details of soundness of samples.

Table-8: Soundness of bricks

S. no	Brick type	Soundness
1	B1	Satisfactory
2	B2	Satisfactory
3	B3	Satisfactory
4	B4	Not Satisfactory
5	B5	Not Satisfactory
6	B6	Not Satisfactory

The bricks were dipped into separate containers for a period of 28 days and the water in which the bricks were dipped was tested and compared to fresh water before dipping. Comparison was done on certain parameters like pH, conductivity, turbidity, hardness and the amount of chlorides.

H. pH Test

pH of water in which bricks were dipped was tested for a period of 7 days, 21 days and 28 days and compared with fresh water. The table 9 below shows the value for pH test.

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Table-9: pH test of bricks

S. no.	Brick type	Fresh Water	7 day	21 Day	28 Day
1	B1	7.3	7.31	7.78	8.58
2	B2	7.3	7.68	7.79	8.59
3	B3	7.3	7.68	7.82	8.61
4	B4	7.3	7.83	7.92	8.69
5	B5	7.3	7.71	7.81	8.65
6	B6	7.3	7.84	7.92	8.71

Fig 4 below shows the test conducted on pH meter and its calibration.

Fig 4: pH meter

I. Conductivity Test

Samples prepared were also tested for conductivity for a period of 7 days, 21 days and 28 days and were compared with fresh water used to dip the samples. The table 10 below shows conductivity of samples

Table-10 Conductivity test of bricks

S. no.	Brick type	7 day	21 Day	28 Day
1	B1	0.901	0.922	1.280
2	B2	0.911	0.931	1.365
3	B3	0.983	0.990	1.792
4	B4	1.215	1.430	1.927
5	B5	1.220	2.58	2.650
6	B6	1.310	2.828	2.640

Fig 5 below shows the conductivity tests performed on water sample dipped with bricks.

Fig 5: Conductivity test

J. Hardness Test

Hardness of water in which bricks were dipped was tested for a period of 7 days, 21 days and 28 days and compared with fresh water. The table 11 below shows the value for test.

Table-1:1 Hardness test of bricks

S. no.	Brick type	7 day	21 Day	28 Day
1	B1	375	1062.5	1212.5
2	B2	400	700	800
3	B3	525	912.5	900
4	B4	800	1180	1350
5	B5	775	2225	2250
6	B6	825	2540	2800

Fig 6 below shows chemical tests performed on water sample in which bricks were dipped for hardness test.

Fig 6: Hardness test

K. Chloride Test

Chloride of water in which bricks were dipped was tested for a period of 7 days, 21 days and 28 days and compared with fresh water. Figure 7 shows the chloride test in chemical lab on water in which bricks were dipped. The table 12 below shows the value for chlorides test.

Fig 7: Chloride test

Table-12 Chlorides test of bricks

S. no.	Brick type	7 day	21 Day	28 Day
1	B1	79.97	82.98	86.64
2	B2	74.98	84.98	89.97
3	B3	69.98	74.35	89.47
4	B4	89.97	87.97	91.48
5	B5	89.97	84.98	94.98
6	B6	109.96	109.48	116.47

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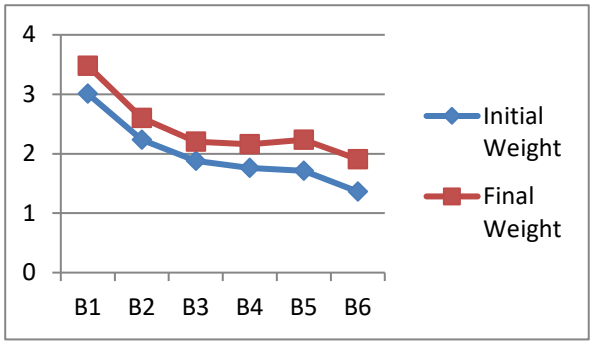
III. RESULTS AND DISCUSSIONS

The results and properties of various mixes tested are shown below.

A. Weight

The weight results show that all the bricks are light in weight as compared to the standard brick B1 which does not contain any quantity of slump. So, all the bricks are light weight bricks, which is an advantage in construction.

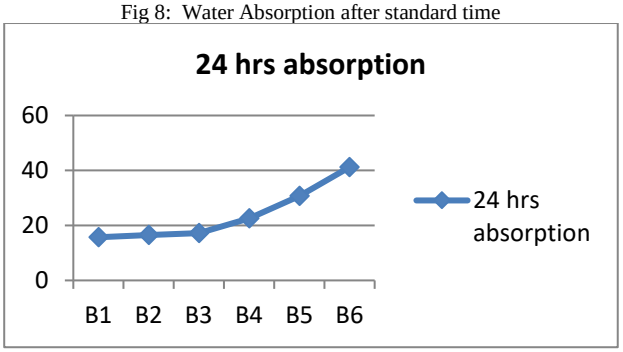
Fig 7: Initial and final weight after absorption



B. Water Absorption

According to the Indian standards, water absorption for class I and class II bricks should not be more than 20% after 24 hours immersion. The result of water absorption shows that the samples B1, B2 and B3 have absorption under standard value and hence acceptable. But the rest of the samples have a greater amount of absorption. Fig 7 and 8 shows the comparison of initial and final weight and percentage of water absorption respectively.

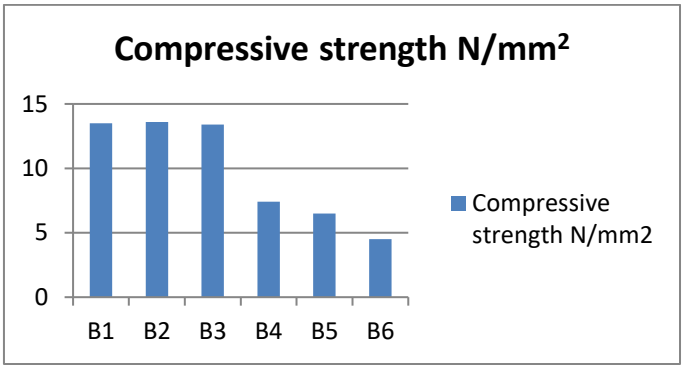
Fig 8: Water Absorption after standard time



C. Compressive Strength

The result of compressive strength shows that, the compressive strength of brick can be maintained within standard acceptable limits by addition of sludge to a limited quantity of 10% and 20% i.e. B2 & B3, but the compressive strength of brick mix will decrease on excess addition of slump i.e. more than 20%. Fig 9 shows the comparative study of compressive strength test results of various mixes.

Fig 9: Compressive strength of bricks



D. Efflorescence Test

According to IS:3495 part-3 1992, When there is no perceptible deposit, efflorescence is NIL, but there is slight efflorescence when 10% of exposed area has thin deposit of salts. In our specimens, samples with 0, 10 and 20% sludge have nil efflorescence but the rest have slight efflorescence.

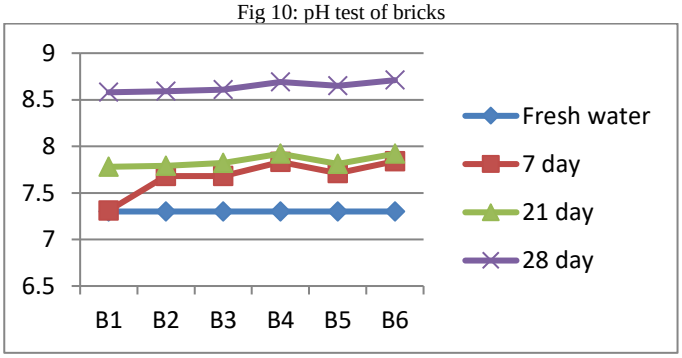
E. Soundness Test

A brick is sound only if it does not break and ringing sound is produced. The bricks with 10% and 20% sludge are sound and can be used for construction.

F. pH Test

According to Indian standards, the samples with greater pH have low risk of corrosion. So, all our samples have pH greater than 7 and thus are less prone to corrosion. Fig10 below shows chart of pH value of different samples at different days.

Fig 10: pH test of bricks



G. Conductivity Test

The tests performed show that our specimen brick B1 without any sludge have conductivity less than 1 and so is shown in brick B2 and B3. Hence these bricks are acceptable to use. Fig 11 shows the comparison of conductivity of different samples.

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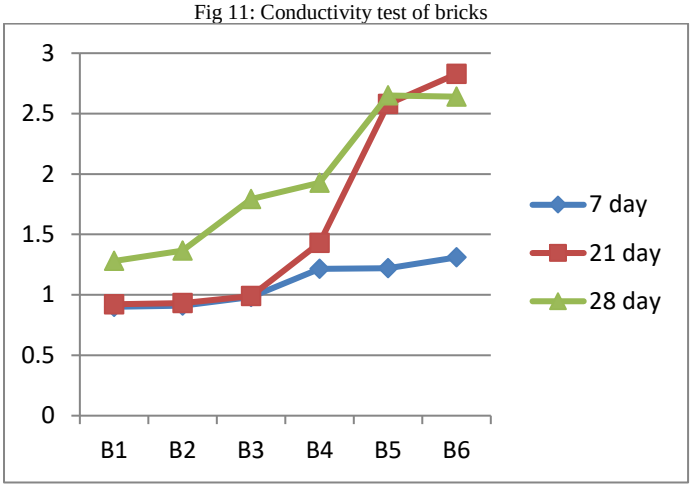
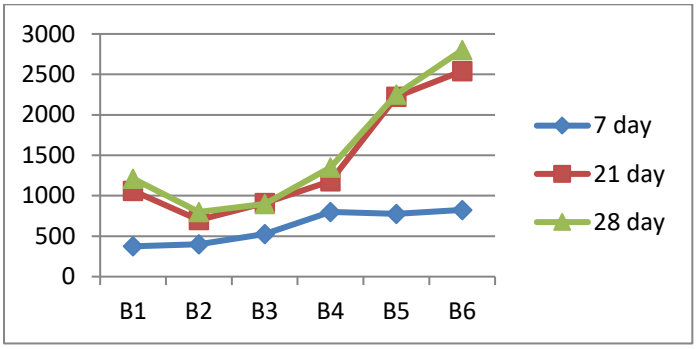
Fig 11: Conductivity test of bricks



H. Hardness Test

When compared to B1 i.e. 0% sludge, we see that B2 and B3 both have almost same hardness which is near to B1 and thus are acceptable. Fig12 below shows the hardness test results of water in which bricks were soaked.

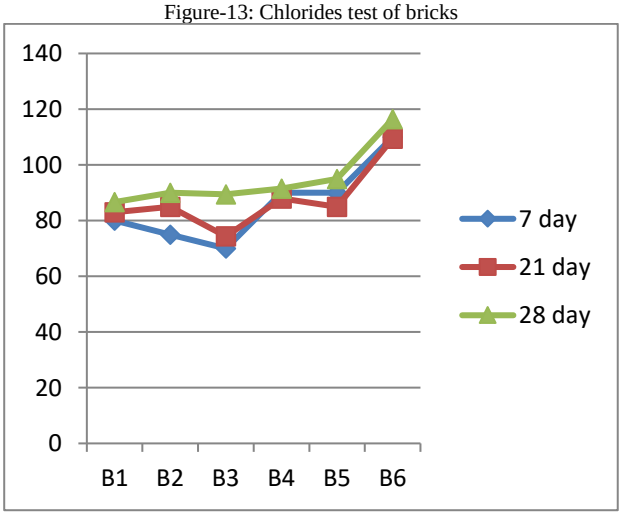
Fig 12 Hardness test of water soaked bricks



I. Chloride Test

The chloride tests show the corrosion prone amount of the bricks. Low values usually are less prone to corrosion. We see that B2 and B3 have lower values of corrosion than the sample brick B1 and then the value increases. So, B1, B2 and B3 are acceptable. Figure 13 below shows the chloride content of various specimens.

Figure-13: Chlorides test of bricks



IV. CONCLUSION

After the experimental investigation of use of toothpaste sludge in following conclusions were made:

- The toothpaste sludge can be utilized as an additive in the form of powder in the production of bricks upto 20% of replacement of soil(clay).
- Light weight materials are formed as we keep increasing the amount the sludge in brick.
- Compressive strength holds well if sludge is added up to 20%, further increasing the percentage of sludge in bricks will lead to decrease in the compressive strength of bricks.
- Addition of sludge in bricks leads to well sounded bricks provided a limited amount of sludge is added.
- Addition of sludge in bricks leads to negligible efflorescence in it provided a limited amount of 20% is added.
- With addition of 20% of sludge there is lower chloride content and higher pH content than the specimen without sludge which means resistance to corrosion.

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